Performance of MODIS Thermal Emissive Bands On-orbit Calibration Algorithms

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Two nearly identical copies of the Moderate Resolution Imaging Spectroradiometer (MODIS) are currently operated on-board the Terra and Aqua spacecrafts, launched in December 1999 and May 2002, respectively. Together, they have produced an unprecedented amount of science data products, which are widely used for the studies of changes in the Earth's system of land, oceans, and atmosphere. MODIS is a cross-track scanning radiometer, which uses a two-sided scan mirror and collects data continuously over a wide scan angle range (+/-55 degree relative to the instrument nadir) each scan of 1.47 seconds. It has 36 spectral bands with wavelengths ranging from visible (VIS) to long-wave infrared (LWIR). MODIS bands 1-19 and 26 are the reflective solar bands (RSB) and bands 20-25 and 27-36 are the thermal emissive bands (TEB). MODIS was developed and designed with improvements made over its heritage sensors (such as AVHRR and Landsat) and, in particular, with more stringent calibration requirements. Because of this, MODIS was built with a set of state-of-art on-board calibrators (OBC), which include a solar diffuser (SD), a solar diffuser stability monitor (SDSM), a blackbody (BB), a spectroradiometric calibration assembly (SRCA), and a space view (SV) port. With the exception of view angle differences, MODIS OBC measurements and the Earth View (EV) observations are made via the same optical path.

MODIS TEB have a total of 160 individual TEB detectors (10 per band), which are located on two cold focal plane assemblies (CFPA). For nominal on-orbit operation, the CFPA temperature is controlled at 83K via a passive radiative cooler. For the TEB, the calibration requirements at specified typical scene radiances are less than or equal to 1% with an exception for the fire detection (low gain) band. MODIS TEB on-orbit calibration is performed on a scan-by-scan basis using a quadratic calibration algorithm, and data collected from sensor responses to the on-board BB and SV. The BB serves as the thermal calibration source and the SV provides measurements for the sensor's background and offsets. MODIS on-board BB is a v-grooved plate with its temperature measured using 12 platinum resistive thermistors (PRT) uniformly embedded in the BB substrate. All the BB thermistors were characterized pre-launch with reference to the NIST temperature standards. Unlike typical BB operations in many heritage sensors, which have no temperature control capability, the MODIS on-board BB can be operated at any temperatures between instrument ambient (about 270K) and 315K and can also be varied continuously within this range. This feature has significantly enhanced the MODIS' capability of

tracking and updating the TEB nonlinear calibration coefficients over its entire mission. Following a brief description of MODIS TEB on-orbit calibration methodologies and its on-board BB operational activities, this paper provides a comprehensive performance assessment of MODIS TEB quadratic calibration algorithm. It examines the scan-by-scan, orbit-by-orbit, daily, and seasonal variations of detector responses and associated impact due changes in the CFPA and instrument temperatures. Specifically, this paper will analyze the contribution by each individual thermal emissive source term (BB, scan cavity, and scan mirror), the impact on the Level 1B data product quality due to pre-launch and on-orbit calibration uncertainties. A comparison of Terra and Aqua TEB on-orbit performance, lessons learned, and suggestions for future improvements will also be made.